A New Early Silurian Species of *Trimerella* (Brachiopoda: Craniata) from the Orange District, New South Wales

Ian G. Percival[1]* and A.J. Wright[2]*

[1]Geological Survey of New South Wales, Department of Primary Industries, State Geoscience Centre, 947-953 Londonderry Road, Londonderry, NSW 2753; [2]School of Earth and Environmental Sciences, University of Wollongong, NSW 2522; *Honorary Research Associate, Centre for Ecostratigraphy and Palaeobiology, Macquarie University, NSW 2109.

Percival, I.G. and Wright, A.J. (2005). A new Early Silurian species of *Trimerella* (Brachiopoda: Craniata) from the Orange district, New South Wales. *Proceedings of the Linnean Society of New South Wales* **126**, 111-120.

Trimerella australis, a new species of craniate brachiopod, is described from silicified material extracted from Early Silurian limestone in the Bowan Park district, 22 km west of Orange in central New South Wales. Accompanying conodonts of the *Distomodus staurognathoides* Zone indicate this unnamed unit is mid Llandovery (latest Aeronian to earliest Telychian) in age, and support correlation with the Cobblers Creek Limestone at the base of the Waugoola Group. As with most other occurrences of trimerellide brachiopods in the Late Ordovician and Early Silurian of the Lachlan Orogen, *T. australis* completely dominates its depauperate faunal associates of corals including *Aphyllum*? sp., cf. *Axolasma* sp. and cf. *Halysites cratus* Etheridge, 1904 , and very rare atrypide brachiopods. Although all specimens of *T. australis* are disarticulated, the community is interpreted as preserved essentially in situ, representing a very shallow water Benthic Assemblage 2 environment.

Manuscript received 5 October 2004, accepted for publication 16 February 2005.

KEYWORDS: Benthic Assemblage, biostratigraphy, Brachiopoda, Craniata, early Silurian, halysitid, tetracorals, trimerellide

INTRODUCTION

Silurian trimerellide brachiopods from the Lachlan Orogen of eastern Australia are poorly known compared to their Late Ordovician predecessors. Only *Keteiodoros bellense* from the Dripstone Formation (Early Silurian, Wenlock) of the Oakdale Anticline, southeast of Wellington, NSW (Strusz et al. 1998), has been fully documented. One other trimerellide specimen, identified by Strusz (1982) as *Trimerella* sp. from the Walker Volcanics of the Canberra area, has been illustrated from Silurian strata in NSW; the age of this occurrence is reported as either Wenlock (Strusz 1982) or early Ludlow (Talent et al. 2003). Unidentified trimerellide material, possibly *Trimerella*, is known from the Manildra district (Savage 1968), in limestone (probably allochthonous) of the Greengrove Formation, the age of which has been interpreted as either lower mid Llandovery (Munson et al. 2000) or mid to late Llandovery (Talent et al. 2003). Here we document the new species *Trimerella australis*, from the Bowan Park district west of Orange, in limestone of mid Llandovery age (*Distomodus staurognathoides* Conodont Zone, equated to the upper *convolutus* to lower *crispus* Graptolite Zones). This new species qualifies as the biostratigraphically most precisely constrained Silurian representative of this order presently known from eastern Australia.

STRATIGRAPHIC SETTING AND AGE

Abundant silicified specimens of the new species of *Trimerella* occur in an unnamed limestone, situated at Grid Reference 672400 mE 6315070 mN (GDA94 co-ordinates) in the Quarry Creek area, east of the Bowan Park district, about 22 km west of Orange (Fig. 1). The limestone was first mapped in detail by Packham and Stevens (1955, fig. 1), who depicted it as two outcrops offset by an east-west fault. Immediately west of the Silurian limestone lie Late Ordovician volcanics equated to the Malachis Hill Formation. To the east, the more northerly outcrop of limestone that yielded the abundant trimerellides abuts

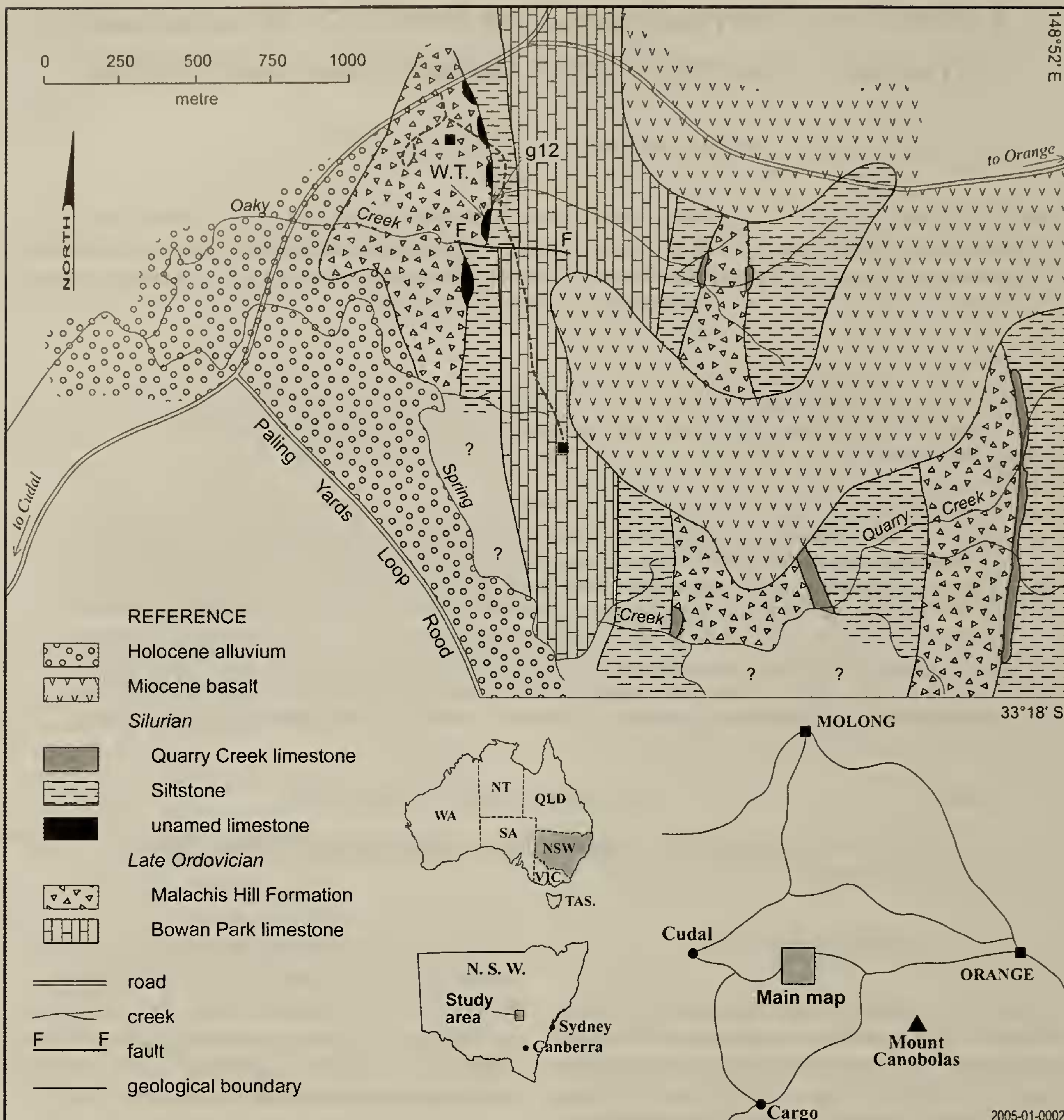

Figure 1. Map of the Quarry Creek area, east of Bowan Park district, 22 km west of Orange, NSW, showing the location of the limestone in the W.T. section of Bischoff (1987) that yielded the trimerellide brachiopods and associated fauna documented in this paper. Geology adapted from Packham and Stevens (1955) and mapping by Packham in Jenkins (1986) and Rickards et al. (1995).

graptolite-bearing beds (g12 locality of Packham and Stevens), considered by those authors to be of late Llandovery age. These graptolitic beds are probably faulted against the limestone. Revised identifications in Rickards et al. (1995, table 1) of many of the late Llandovery graptolite faunas found by Packham and Stevens have indicated that these localities should now be assigned ages in the early to mid Wenlock. R.B. Rickards (pers. comm. 2004) informs us that the graptolite fauna from g12 contains *Testograptus testis* and should be reassigned to the late Wenlock *lundgreni-testis* Biozone. Farther east is limestone of Late Ordovician age, termed the Barton Limestone by Packham and Stevens (1955). Current terminology has seen this name suppressed in favour of the Bowan Park Limestone Subgroup that is extensively developed in the Bowan Park area to the west.

Bischoff (1987) sampled the Silurian limestone (approximately 16 m thick) in his W.T. section, and first recognised its mid Llandovery age, based on conodonts. These were identified by Bischoff as *Aulacognathus angulatus*, *Distomodus staurognathoides* (alpha morphotype), *Oulodus australis*, *O. planus planus*, *Ozarkodina excavata eosilurica* and *Oz. waugoolaensis*; two additional species – *Oulodus panuarensis* and *Pterospathodus cadiaensis* – were very rare in Bischoff's collections. Our sample GSNSW C1892 from the upper part of the limestone, where the trimerellides are particularly abundant, yielded *Oulodus australis*, *O. planus planus*, *Oz. waugoolaensis*, together with *Panderodus* sp. The additional conodont species recorded by Bischoff (1987, table 5), but not identified in our sample, were restricted to the lower part of his W.T. section. Bischoff assigned this conodont fauna to his *Aulocognathus antiquus* – *Distomodus staurognathoides* alpha Assemblage Zone, which he correlated with the lower *turriculatus* Graptolite Zone, possibly extending into the upper part of the preceding *sedgwickii* Graptolite Zone. Simpson (1995) queried the veracity of *A. antiquus*, and argued that Bischoff's assemblage zone bearing this name should be equated with the *Distomodus staurognathoides* Zone of global usage. Uncertainty in interpretation of the *Aulocognathus* lineage proposed by Bischoff only affects the lower limit of the Zone, and Strusz (1996) (following Simpson) aligned the local conodont zone with the interval represented by the *convolutus* to lower *crispus* graptolite zones. This range encompasses the full extent of the age of the W.T. section as interpreted by Bischoff (1987).

The Quarry Creek Limestone is regarded as either late Llandovery or early Wenlock in age (Bischoff 1987). Rickards et al. (1995) discussed possible problems with the conflict in age between this limestone and the overlying Panuara Formation, but this appears to have been resolved with revision of graptolite identifications from the lower part of the latter unit supporting an early Wenlock age. Munson et al. (2000) placed the Quarry Creek Limestone straddling the Llandovery-Wenlock boundary. Although Talent et al. (2003, figure 6) depicted the Quarry Creek Limestone as occupying a lower Wenlock horizon, they admitted the possibility (p. 200) that this unit is entirely upper Llandovery. Whatever its precise age range, the Quarry Creek Limestone is substantially younger than the unnamed limestone of Bischoff's (1987) W.T. section, and the two horizons cannot be equated as shown in Jenkins (1986, figure 34) and Rickards et al. (1995, figure 2).

The unnamed limestone in the W.T. section is thus the oldest Silurian stratum in the Quarry Creek area, and is correlated using conodonts (Bischoff 1987) with the Cobblers Creek Limestone at the base of the Waugoola Group in the Angullong district, SSW of Orange. Recognition of this relationship is significant in constraining the upper limit of the Panuara Hiatus that separates the Ashburnia and Waugoola groups. Krynen and Pogson (in Pogson and Watkins 1998, p.109) interpreted the base of the Waugoola Group as diachronous, ranging from early late Llandovery in the Angullong Syncline succession, to terminal Llandovery (*P. amorphognathoides* Conodont Zone) in the Quarry Creek area. However, the presence of mid Llandovery strata in the W.T. section indicates that the base of the Waugoola Group in the Quarry Creek area is essentially the same age as elsewhere, and hence is isochronous rather than diachronous.

FAUNAL ASSOCIATES AND DEPOSITIONAL ENVIRONMENT

As with almost all other occurrences of trimerellide brachiopods known from the Late Ordovician and Early Silurian of the Lachlan Orogen, *T. australis* is numerically abundant and completely dominates an otherwise depauperate group of faunal associates. As extraction of fossils was by dissolution of bulk limestone samples in dilute acids, the silicified residues obtained are believed to be fairly representative of the preservable elements of the trimerellide community. In the W.T. section, faunal associates comprise the tetracorals cf. *Axolasma* sp. (Fig. 2a, b) and *Aphyllum*? sp. (Fig. 2d-f), the halysitid tabulate coral cf. *Halysites cratus* Etheridge, 1904 (Fig. 2c), an indeterminate finely-ribbed atrypide brachiopod (Fig. 2g-i) and a smooth atrypide (Fig. 2j). Each of these taxa is represented by at most a few specimens only, compared to many dozens of *T. australis* valves (although a high proportion of the latter are fragmentary, due either to post-mortem breakage or, more likely, incomplete silicification). One example of *Aphyllum*? is preserved on the exterior surface of a dorsal valve of *T. australis*, with the calyx adjacent to the anterior margin (Fig. 3p). Possibly the coral not only employed the trimerellide as a substrate but could also have obtained nutrients from the inhalant or exhalant currents of the living brachiopod. All examples of *T. australis* are disarticulated valves, probably resulting from storm or current activity disturbing in situ specimens or redistributing deceased individuals (cf Webby and Percival 1983). Orientation of shells is generally horizontal, and erratic rather than consistently either convex up or down.

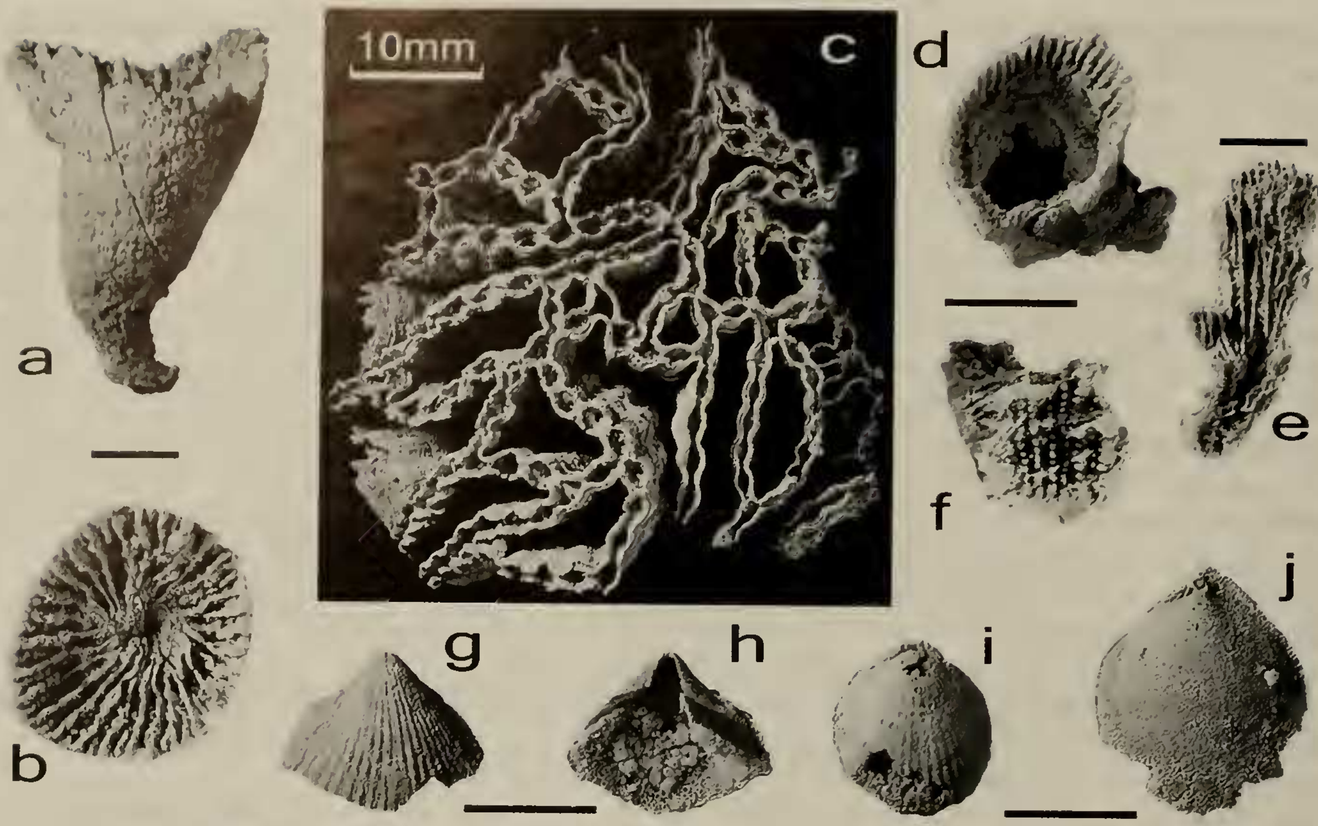

Figure 2. Corals and articulate brachiopods associated with *Trimerella australis*. All specimens silicified; scale bars in black represent 5 mm. (a, b) cf. *Axolasma* sp., MMF 44114, lateral and calical views, displaying axial vortex. (c) cf. *Halysites cratus* Etheridge, 1904, MMF 44115, with calical views of partial colony. (d-f) *Aphyllum*? sp., oblique view of calyx, MMF 44116, longitudinal broken fragment, MMF 44117 showing septa and budding, and fragment of interior of calyx, MMF 44118 displaying acanthine septa. (g, h) indeterminate ribbed atrypide, external and internal views of partial ventral valve and fragment of attached dorsal valve, MMF 44119. (i) external view of dorsal valve of conjoined specimen of ribbed atrypide, MMF 44120. Note circular pitting on surface, possibly caused by predatory sponge. (j) dorsal view of conjoined valves of smooth atrypide, MMF 44121.

Comparable trimerellide communities include Late Ordovician shell beds consisting of *Eodinobolus stevensi* in the lower Fossil Hill Limestone at Cliefden Caves and Daylesford Limestone at Bowan Park (Webby and Percival 1983, Percival 1995), and *Belubula spectacula* in the Belubula Limestone at Cliefden Caves (Percival 1995). *Keteiodoros bellense* from the Dripstone Formation (Wenlock) of the Oakdale Anticline (Strusz et al. 1998) is the only locally-documented Silurian example of an in situ trimerellide community. The Late Ordovician examples from Cliefden Caves and Bowan Park were assigned to a Benthic Assemblage 1 or upper B.A. 2 depositional setting, equivalent to a marine shoreline (intertidal to very shallow subtidal) environment (Percival and Webby 1996). Ordinarily this would be in protected waters such as a lagoon or embayment, as trimerellides – lacking a pedicle attachment – relied on posterior gravity weighting for stability of orientation when alive. Such shallow waters are also highly susceptible to disturbance during storms, accounting for death assemblages and stacked shell beds commonly encountered in trimerellide occurrences. Strusz et al. (1998) attributed to *Keteiodoros bellense* in the Dripstone Formation a B.A. 2 (shallow subtidal) setting, in quiet waters inshore of a protective *Palaeophyllum* wave barrier.

We found no evidence of a protective wave barrier, such as might have been formed by coral thickets or reefs, associated with the *T. australis* shell beds. However, comparable halysitid tabulates and solitary tetracorals associated with this occurrence, and also with *Keteiodoros bellense*, suggest that the depositional environments of these Silurian trimerellides were similar. The stratigraphic position of the *T. australis* shell beds, in limestone deposited following the erosional Panuara Hiatus, also argues for very shallow water, nearshore conditions. Therefore, a quiet water depositional environment no deeper than B.A. 2, and possibly as shallow as B.A. 1, is interpreted for this unit.

SYSTEMATIC PALAEONTOLOGY

Phylum BRACHIOPODA
Class CRANIATA Williams, Carlson, Brunton, Holmer and Popov, 1996
Order TRIMERELLIDA Goryansky and Popov, 1985
Superfamily TRIMERELLOIDEA Davidson and King, 1872
Family TRIMERELLIDAE Davidson and King, 1872
Genus *Trimerella* Billings 1862

Type species

Trimerella grandis Billings, 1862, by subsequent designation of Dall (1870).

Diagnosis

Shell dorsibiconvex, elongate triangular; ventral valve flattened, ventral interarea high, triangular, apsacline, with deep concave homeodeltidium occupying more than half of interarea; dorsal valve strongly convex, beak incurved; ventral umbonal cavities small or vestigial; both valves with distinctly raised visceral platforms, extending anterior of centre; visceral platforms with deep vaults, separated by median partition extending anterior to platform; dorsal hinge plate high, strongly incurved; dorsal *vascula lateralia* broad, slightly divergent, lacking trace of bifurcation (Popov and Holmer 2000, p.185).

Species included:

?*T. asiatica* Li, 1984; *T. jiangshanensis* (Li, 1984) (formerly *Prosoponella*) and *T. zhoujiashanensis* (Li and Han, 1980) (formerly *Machaerocolella*) – both genera synonymised with *Trimerella* by Percival (1995) and Popov et al. (1997); all preceding species from Late Ordovician (early Ashgill) Huangnehkang Formation, Jiangshan county, W. Zhejiang, China (according to Rong and Li 1993).

T. attentuata Goryansky, 1972 from Early Silurian (late Llandovery to early Wenlock) Donenzhal Formation, Kazakhstan (Popov et al. 1997).

T. acuminata Billings, 1862 from Silurian (Wenlock-Ludlow) Guelph Limestone, Ontario (Popov and Holmer 2000, p. 186); Niagara Group, Ohio and Illinois; Gotland and Faro islands, Sweden; Gorno Altay of Russia (Kul'kov 1967).

T. billingsi Dall, 1871 from Silurian (Wenlock-Ludlow) Guelph Limestone, Ontario.

T. grandis Billings, 1862 from Silurian (Wenlock-Ludlow) Guelph Limestone, Ontario; Niagara Group, Ohio.

T. lindstroemi (Dall, 1870) from Silurian (Wenlock) Högklint beds, Gotland (Popov and Holmer 2000, p. 186) and (Ludlow) Klinteberg Limestone, Gotland (Cocks in Murray 1985, p. 55).

T. ohioensis Meek, 1871 from Silurian (Wenlock-Ludlow) Guelph Limestone, Ontario; Niagara Group, Ohio and New York (Popov and Holmer 2000, p. 186).

T. wisbyensis Davidson and King, 1874 from Early Silurian (Wenlock) of Gotland and Estonia.

Trimerella australis sp. nov.
Fig. 3a-q, Fig. 4a-b

Type material

Holotype MMF 44100; paratypes MMF 44101-44113, from unnamed Early Silurian limestone on 'Coorombong' property, east of the Bowan Park district, about 22 km west of Orange, NSW. All specimens curated in the NSW State Palaeontological Reference Collection, held at the Geological Survey of NSW Geoscience Centre, Londonderry.

Diagnosis

Broadly acuminate *Trimerella* with vestigial to shallow ventral umbonal chambers; narrow ventral platform divided medially by parallel-sided furrow, and deeply excavated beneath by twin vaults; dorsal platform supported by median septum longer than rudimentary counterpart in ventral valve but terminating well short of anterior margin.

Description

Dorsibiconvex shell apparently lacking external ornament or pronounced growth lamellae; widest at, or slightly anterior to, midlength. As all specimens are fragmentary, overall dimensions are estimated from reconstructions (Fig. 4); maximum width approximates 45-50 mm, and maximum length is probably at least 60 mm for ventral valves, and about 45 mm for brachial valves. Height of conjoined valves estimated at no more than 20 mm.

Ventral valve broadly acuminate with posterolateral margins forming a right angle at slightly incurved beak; pseudointerarea apsacline to orthocline. Homeodeltidium shallowly depressed, marked by incised flattened chevrons and extending to about one-third width of pseudointerarea at anterior edge (Fig. 3a); homeodeltidium delineated from elongate triangular propareas by incised groove; deltidial ridges lacking, except in one possibly immature individual where the lateral margins of the homeodeltidum are slightly raised (Fig. 3g). A depressed flattened area immediately in front of the

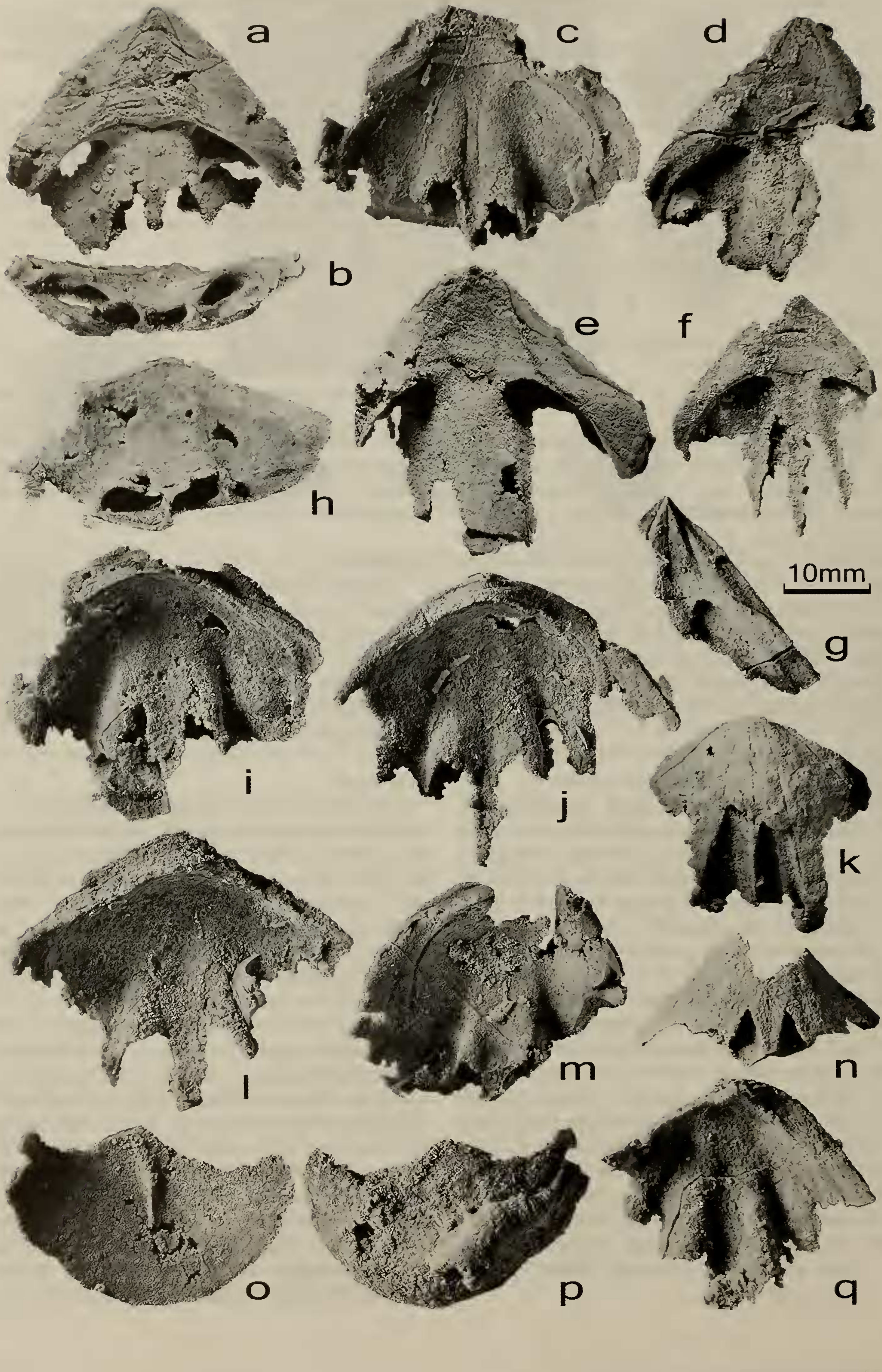
a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
10mm

Figure 3. (LEFT) *Trimerella australis* sp. nov. from unnamed Lower Silurian limestone near Quarry Creek. a-b is the holotype, all other figured specimens are paratypes. All specimens 1.5 times natural size. (a, b) internal view of posterior fragment of ventral valve showing pseudointerarea, and oblique view of specimen to display umbonal and platform chambers, MMF 44100. (c) internal view of finely preserved posterior fragment of ventral valve, showing vaulted platform, MMF 44101. (d) internal view of posterior fragment of ventral valve showing pseudointerarea, MMF 44102. (e) internal view of posterior fragment of ventral valve showing pseudointerarea and platform, MMF 44103. (f) internal view of posterior fragment of ventral valve showing pseudointerarea and eroded platform represented by lateral and medial walls of chambers, MMF 44104. (g) internal view of posterior fragment of ventral valve showing partial pseudointerarea, MMF 44105. (h, i) internal view of posterior fragment of dorsal valve, oriented obliquely to show platform chambers, h, and normal view showing platform, i, MMF 44106. (j) internal view of posterior fragment of dorsal valve, showing pseudointerarea and platform, MMF 44107. (k) external view of posterior part of dorsal valve, partially eroded anteriorly revealing interior of platform chambers, MMF 44108. (l) internal view of posterior fragment of dorsal valve, showing pseudointerarea and platform, MMF 44109. (m) internal view of posterior fragment of dorsal valve, showing platform and marginal area, MMF 44110. (n) external view of fragment of ventral? valve, partially eroded anteriorly revealing interior of platform chambers, MMF 44111. (o, p) internal and external views of anterior fragment of dorsal valve showing median septum, o, and tetracoral *Aphyllum*? sp. growing adjacent to valve margin, p, MMF 44112. (q) internal view of posterior fragment of dorsal valve, showing platform, MMF 44113.

anterior edge of the pseudodeltidium may represent the site of a very weakly impressed umbonal muscle scar (Fig. 3a, c, f). Umbonal chambers variably developed even in fully grown specimens, where they may be rudimentary (Fig. 3c) or shallowly excavated (Fig. 3a, b, d, e, f) beneath pseudointerareas, but are always less prominent than visceral platform chambers (Fig. 3b, c, n). Cardinal buttress absent, instead replaced by distinct narrow parallel-sided median furrow slightly depressed below level of adjacent visceral platform (Fig. 3a, c), although this feature is not always apparent (Fig. 3e). Platform surface smooth, lacking traces of muscle scars, and narrowly rounded, reflecting conical vaulted chambers that extend to posterior end of cardinal buttress furrow. V-shaped anterior extremity of platform supported by very short median septum not extending beyond mid-length of valve. Lateral muscle scars, inserted along crescentic

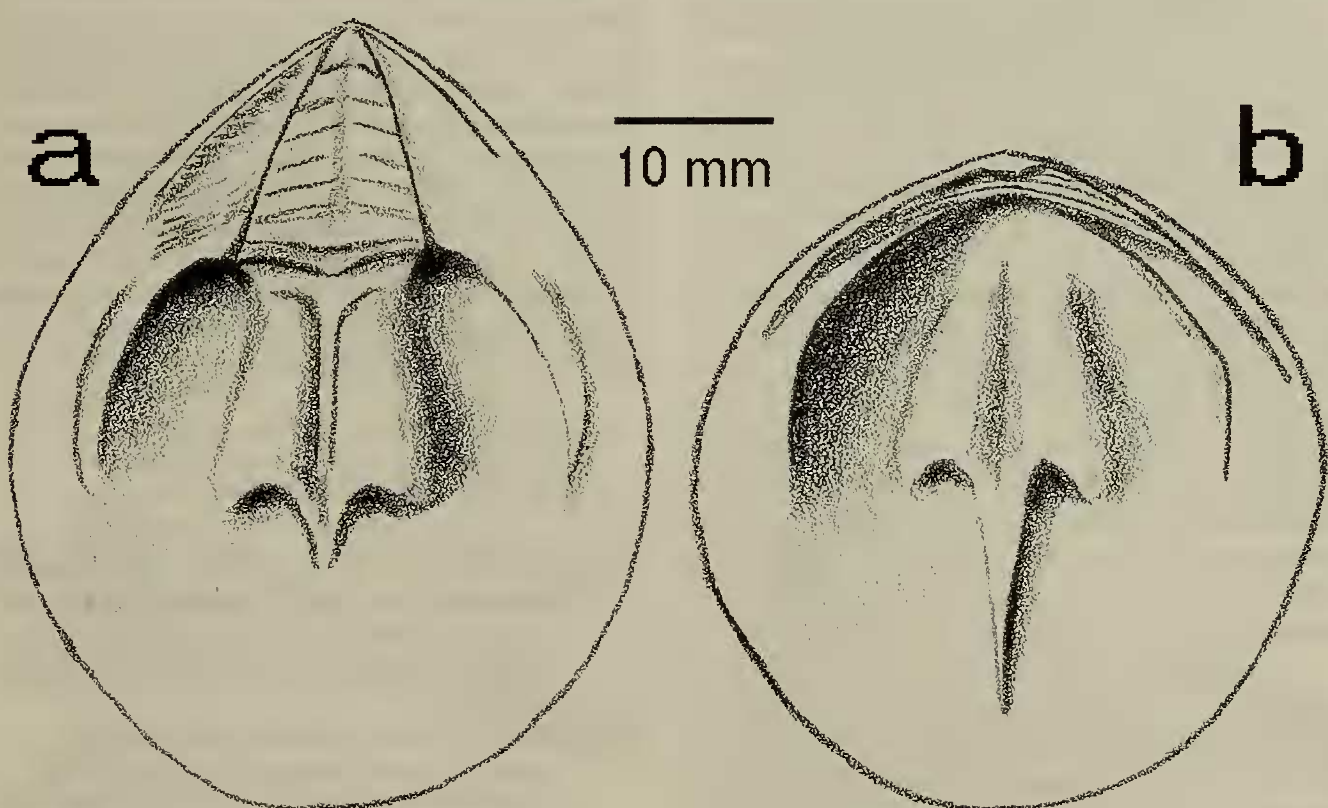

Figure 4. Reconstructions of (a) ventral and (b) dorsal valves of *Trimerella australis*.

furrows parallel to valve margins, prominent in some specimens (Fig. 3c). Pallial canals not visible.

Dorsal valve elongately ovate, with rounded to subangular beak that tends to be slightly to markedly asymmetric, and is gently to moderately incurved (Fig. 3j, l). Brachidial plate curvilinear, prominent but relatively low, occupying all of very low pseudointerarea that expands and merges laterally with broad marginal area raised slightly above valve floor; incised boundary between marginal area and valve floor Fig. 3m) may equate to crescent of previous authors. Marginal area indistinguishable anterior to midlength. Umbonal chambers lacking; umbonal muscle scar not apparent. Visceral platform narrow, distinctly vaulted with long conical chambers beneath (Fig. 3h, i, k); ventral surface strongly convex, bisected longitudinally by broad shallow median depression (Fig. 3j, m, q). No trace of muscle scars on visceral platform, which does not extend into anterior half of valve. Anterior edge of wall separating vaults beneath platform is continuous with thin low median septum, much longer than its counterpart in ventral valve but ending well short of anterior valve margin; the median septum on the one specimen available (Fig. 3o, Fig. 4b) is estimated to terminate between three-quarters and four-fifths valve length. Internal shell surface smooth; no pallial canals discernible.

Remarks

Trimerella attentuata Goryansky, 1972 (revised by Popov et al. 1997), from the late Llandovery to early Wenlock Donenzhal Formation of Kazakhstan, is closest in age and general appearance to the new species. It differs in being much smaller (attaining just half the dimensions of *T. australis*), and in the relatively longer extension of the visceral platform and median septum in the dorsal valve. The ventral platform of *T. attenuata* is relatively wide and in two figured specimens (Popov et al. 1997) bears prominent diagonal growth lines, whereas that of *T. australis* is narrow and smooth. There does, however, appear to be a comparable narrow median furrow developed on the platform of both species, and neither displays any conspicuous extension of a median septum anterior to the ventral platform. All illustrated examples of *T. attenuata* are internal moulds that do not adequately reveal details of the pseudointerareas.

Comparisons with previously established Wenlock to Ludlow species are also hindered by significant differences in preservation. These species of *Trimerella* were originally defined on the basis of natural internal moulds that frequently lacked details of pseudointerareas and visceral platform surfaces. All of the species depicted by Davidson and King (1874) and Hall and Clarke (1892) have been reconstructed with elongate median septa, that in the case of the dorsal valve extend almost to the anterior margin of the valve, unlike *T. australis*. The new species also seems to be compressed dorsoventrally compared with most Wenlock to Ludlow forms. Few of these have been photographically illustrated in the 130 years since Davidson and King's (1874) monograph, but figures in the Treatise (Popov and Holmer 2000, p. 187) confirm the differences discussed above between all these species and *T. australis*.

From species of *Trimerella* described from the Late Ordovician (early Ashgill) Huangnehkang Formation of Jiangshan county, W. Zhejiang, China (Li and Han 1980, Li 1984), *T. australis* is readily distinguished by its relatively deeply excavated ventral platform chambers and absence of a well-developed median septum extending anterior to this platform. Dorsal valves of both ?*T. asiatica* and *T. zhoujiashanensis* are inadequately known and cannot be compared with that of *T. australis*. The new species is furthest removed morphologically from *T. jiangshanensis* (characterised by the presence of stout median septa extending to the margins of both valves).

ACKNOWLEDGMENTS

The presence of trimerellides in the unnamed limestone of Bischoff's W.T. section was discovered during field studies in 1998 by Jonathan Dunningham of Emmanuel College, Cambridge. We are grateful to the owners of 'Coorombong' for access to their property. Preparation of the fragile silicified specimens was skilfully carried out by Gary Dargan, who dissolved the enclosing limestone in dilute hydrochloric acid. David Barnes carefully photographed the specimens and compiled the digital plates. Reviews by two anonymous referees were helpful in improving the final version of this paper. Publication by Percival is authorised by the Director of the Geological Survey of NSW.

REFERENCES

Billings, E. (1862). New species of fossils from different parts of the lower, middle and upper Silurian rocks of Canada. 'Palaeozoic fossils', vol. 1, 96-185. Canadian Geological Survey. (Dawson Brothers, Montreal).

Bischoff, G.C.O. (1987). Early and Middle Silurian conodonts from midwestern New South Wales. *Courier Forschungsinstitut Senckenberg* **89**, 1-337 [imprint 1986].

Dall, W.H. (1870). A revision of the Terebratulidae and Lingulidae. *American Journal of Conchology* **6**,

88-168.
Dall, W.H. (1871). Supplement to the revision of the Terebratulidae and Lingulidae, with additions, corrections, and a revision of the Cranidae and Discinidae. *American Journal of Conchology* **7**, 39-85.
Davidson, T. and King, W. (1872). Remarks on the genera *Trimerella, Dinobolus* and *Monomerella. Geological Magazine* **9**, 442-445.
Davidson, T. and King, W. (1874). On the Trimerellidae, a Palaeozoic family of the Palliobranchs or Brachiopoda. *Quarterly Journal of the Geological Society of London* **30**, 124-172.
Etheridge, R., Jr (1904). A monograph of the Silurian and Devonian corals of New South Wales, with illustrations from other parts of Australia. Part 1. – The genus *Halysites. Memoir of the Geological Survey of New South Wales, Palaeontology* **13**, 39 pp.
Goryansky, V. Yu. (1972). Tip Brachiopoda, Klass Inarticulata. In 'Novye vidy drevnikh rasteniyi bespozvonochnykh SSSR', Vyp. 3 (ed. I.Ye. Zanina), pp. 169-173. (Nauka, Moskva).
Goryansky, V. Yu. and Popov, L.E. (1985). Morfologiya, sistematicheskoye polozheniye i proiskhozhdeniye bezzamkovykh brakhiopod s karbonatnoy rakovinoy [The morphology, systematic position, and origin of inarticulate brachiopods with calcareous shells]. *Paleontologicheskiy Zhurnal* **1985(3)**, 3-14.
Hall, J. and Clarke, J.M. (1892). 'An introduction to the study of the genera of Palaeozoic Brachiopoda'. Natural History of New York, Palaeontology vol. 8, part I. Geological Survey of New York. (Charles van Benthuysen and Sons, Albany).
Jenkins, C.J. (1986). 'The Silurian of mainland southeastern Australia: a field guide'. International Union of Geological Sciences, Silurian Subcommission. 81 pp. (University of Sydney).
Kul'kov, N.P. (1967). 'Brakhiopody i stratigrafiya Silura Gornogo Altaya'. 151 pp. (Nauka, Moskva).
Li, L-Z. (1984). New materials of Ordovician Trimerellidae (Brachiopoda) from western Zhejiang. *Acta Palaeontologica Sinica* **23**, 775-781 [Chinese, with English summary].
Li, L-Z. and Han N-R. (1980). Discovery of Ordovician Trimerellidae (Brachiopoda) from western Zhejiang and its significance. *Acta Palaeontologica Sinica* **19**, 8-21 [Chinese, with English summary].
Meek, F.B. (1871). Preliminary notice of a new species of *Trimerella*, from Ohio. *American Journal of Science and Arts* (series 3) **1**, 305-306.
Munson, T.J., Pickett, J.W. and Strusz, D.L. (2000). Biostratigraphic review of the Silurian tabulate corals and chaetetids of Australia. *Historical Biology* **15**, 41-60.
Murray, J.W., ed. (1985). 'Atlas of invertebrate macrofossils'. (Longman Group, Harlow, Essex).
Packham, G.H. and Stevens, N.C. (1955). The Palaeozoic stratigraphy of Spring and Quarry Creeks, west of Orange, N.S.W. *Journal and Proceedings of the Royal Society of New South Wales* **86**, 55-60.
Percival, I.G. (1995). *Eodinobolus* and related trimerellid brachiopods from the Late Ordovician of New South Wales. *Memoir of the Association of Australasian Palaeontologists* **18**, 41-60.
Percival, I.G. and Webby, B.D. (1996). Island Benthic Assemblages: with examples from the Late Ordovician of Eastern Australia. *Historical Biology* **11**, 171-185.
Pogson, D.J. and Watkins, J.J. (1998). 'Bathurst 1:250 000 Geological Sheet SI/55-8: Explanatory Notes'. 430 pp. (Geological Survey of New South Wales, Sydney).
Popov, L.E. and Holmer, L.E. (2000). Trimerellida. In 'Treatise on Invertebrate Paleontology' (ed. R.L. Kaesler), Part H, Brachiopoda (Revised). Vol. 2. Linguliformea, Craniiformea, and Rhynchonelliformea (part), pp. 184-192. (Geological Society of America, Boulder, Colorado and The University of Kansas, Lawrence, Kansas).
Popov, L.E., Holmer, L.E. and Goryansky, V. Yu. (1997). Late Ordovician and early Silurian trimerellide brachiopods from Kazakhstan. *Journal of Paleontology* **71**, 584-598.
Rickards, R.B., Packham, G.H., Wright, A.J. and Williamson, P.L. (1995). Wenlock and Ludlow graptolite faunas and biostratigraphy of the Quarry Creek district, New South Wales. *Memoir of the Association of Australasian Palaeontologists* **17**, 1-68.
Rong, J-Y. and Li, L-Z. (1993). *Costitrimerella*, a new genus of trimerelloid brachiopod from Huangnekang Formation (early Ashgill), Jiangshan, western Zhejiang, East China. *Acta Palaeontologica Sinica* **32**, 129-140. [Chinese, with English summary].
Savage, N.M. (1968). The geology of the Manildra district. *Journal and Proceedings of the Royal Society of New South Wales* **101**, 159-169.
Simpson, A. (1995). Silurian conodont biostratigraphy in Australia: A review and critique. *Courier Forschungsinstitut Senckenberg* **182**, 325-345.
Strusz, D.L. (1982). Wenlock brachiopods from Canberra, Australia. *Alcheringa* **6**, 105-142.
Strusz, D.L. (1996). Timescales 3. Silurian. Australian Phanerozoic Timescales, biostratigraphic charts and explanatory notes, second series. *Australian Geological Survey Organisation Record 1995/32*, 30 pp.
Strusz, D.L., Percival, I.G., Wright, A.J., Pickett, J.W. and Byrnes, A. (1998). A giant new trimerellide brachiopod from the Wenlock (Early Silurian) of New South Wales, Australia. *Records of the Australian Museum* **50**, 171-186.
Talent, J.A., Mawson, R. and Simpson, A. (2003). Silurian of Australia and New Guinea: biostratigraphic correlations and paleogeography. In 'Silurian lands and seas: paleogeography outside of Laurentia (eds. E. Landing and M.E. Johnson). *New York State Museum Bulletin* **493**, 181-219.
Webby, B.D. and Percival, I.G. (1983). Ordovician trimerellacean brachiopod shell beds. *Lethaia* **16**, 215-232.

Williams, A., Carlson, S.J., Brunton, H.C., Holmer, L.E. and Popov, L. (1996). A supra-ordinal classification of the Brachiopoda. *Philosophical Transactions of the Royal Society, London, Series B* **351**, 1171-1193.